Submerged Aquatic Vegetation Habitat Requirements: A Third Technical Synthesis

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Overview

- There have been two previous Technical Syntheses, 1992 and 2000 which defined water quality habitat requirements (HRs) for SAV, mostly clarity related parameters and nutrients.
- These HRs have stood the test of time, but there was room for improvement

- The original HRs were developed by assessing what necessary for *persistence* of a SAV bed
- On-the-ground restoration demonstrated that different water quality conditions are needed to go from unvegetated bottom to having a sustainable grass bed

- In addition to revising HRs, other factors needed further consideration for management of SAV
  - Climate Change
  - Impact of extreme events
  - Feed-back loops of SAV on water quality
  - Changes in species diversity and community structure over time
  - Resilience of SAV beds – the role of genetic diversity, connectivity and seed banks
  - Land use and shoreline management
  - Ecosystem services provided by SAV

21 Participants

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Response and resilience of submersed aquatic vegetation to extreme weather events (**Gurbisz**, Kemp, Golden, Tanner)

- Light limitation
  - Rain storms produce inputs of sediments, directly blocking light
    - These turbidity pulses can linger (on the scale of years) due to resuspension of unconsolidated material
  - Large pulses of N and P fuel algal blooms
  - These impacts can be mitigated by:
    - Species and genetic diversity
    - Feedback loops within large grass beds.

- Physical disturbance (waves and currents)
  - Plants can be dislodged or uprooted by wind-waves and high velocity flows.
  - These are mitigated by SAV bed canopy drag attenuating both vertical (waves) and horizontal movement (flow)
    - Canopy drag can also divert flows away from shoals and into the channels
- Response to heat waves (next chapter)

- Factors influencing SAV bed resilience
  - Size of the SAV bed
  - Magnitude of the event
  - Timing of event (T.S. Agnes vs T. S. Lee)
  - Condition of bed (i.e. is bed already light-stressed or fairly robust)
  - Diversity
- Future Work
  - Examine synergistic effects of chronic stressors with pulsed events
  - Analysis of WQ data associated with extreme events relative to HRs

21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Arnold, Engelhart, Stevenson, Zimmerman

- The Chesapeake will likely transition from a temperate to a subtropical estuary during the 21st century, as a result of changing climate conditions

- Three components of climate change will impact Chesapeake Bay SAV directly: increasing temperatures, sea level rise, and coastal zone acidification

- Our understanding of how these stressors effect SAV directly is increasing and, coupled with regional climate forecasts, permits us to make basic predictions for the future of bay grasses.

- Climate warming has already been implicated in die-offs of submerged vegetation, especially eelgrass (*Z. marina*). Continued warming has been predicted to reduce and possibly eliminate eelgrass from the Chesapeake Bay

- The “CO2 fertilization effect” of coastal acidification has the potential to stimulate photosynthesis and growth in submerged vegetation, when they are carbon limited. High CO2 / low pH conditions predicted to occur during this century are likely to offset the deleterious effects of thermal stress, facilitating the survival of eelgrass in the Chesapeake Bay

- Our predictions are limited, however, by our poor understanding of the indirect effects of climate change on community members, including fouling organisms, grazers, and microbes associated with seagrass die-offs. These indirect effects are likely to trigger abrupt, unforeseen changes in these communities

Shifting patterns in SAV species diversity and community structure **Rybicki**, Engelhart Tanner, Orth

- Case study- Susquehanna Flats
  - High species diversity in 1971 (8spp.)
  - Low diversity in surveys 1974 to 1984 (1sp)
  - High gain in later years (5 to 10 spp.)
  - Diversity is negatively correlated with *in situ* CHLA, TSS and DIP and negatively correlated with Susquehanna River TN and TP inputs
  - Proportion of exotics in community positively correlated with TN inputs from WTP
  - Natives negatively correlated with WTP and River Input TN

- Case study- Chickahominy River
  - 3 species present, *Hydrilla verticillata*, *Najas minor*, *Ceratophyllum demersum*
  - Generally, exotics and the native spp. abundance are positively correlated
  - *N. minor* grows earlier in the season than *H. verticillata*, giving it a competitive advantage
  - However, during a drought in 2001, 2002 *N. minor* populations declined dramatically due to increased salinity, allowing *H. verticillata* to colonize more area

- Case study – York River
  - Only two species *Zostera marina* and *Ruppia maritima*
  - Eelgrass dominates community nominally
  - Widgeon grass dominates after a perturbation
  - However, once favorable conditions return, eelgrass out competes the widgeon grass
- Detailed analysis of species composition is pending for 21 or more segment

Resilience of SAV beds – the role of genetic diversity, connectivity and seed banks (**Engelhart,** Neel, Orth)

- Declines in SAV can mean;
  - remaining SAV populations may not support the genetic diversity necessary to resist or adapt to environmental change
  - reduced connectivity among remaining SAV patches may preclude dispersal and gene flow among populations
  - diminished SAV seed banks may not allow rapid recovery of a population after a disturbance.

SAV genetics is still a new field
There are relatively few papers

Species	native	Chesapeake Bay	Total worldwide
Ceratophyllum demersum	Yes	0	1
Elodea canadensis	Yes	0	1
Hydrilla verticillata	No	0	1
Potamogeton crispus	Yes	0	0
Potamogeton nodosus	Yes	0	0
Potamogeton perfoliatus	Yes	0	0
Potamogeton pusillus	Yes	0	1
Ruppia maritima	Yes	0	0
Stuckenia pectinata	Yes	0	4
Vallisneria americana	Yes	2	4
Zannichellia palustris	Yes	0	1
Zostera marina	Yes	5	47
TOTAL for Chesapeake Bay species		7	60

- Eelgrass in Chesapeake Bay has medium genetic diversity compared to other systems world-wide
- Restored eelgrass beds have similar genetic diversity to donor beds
- Small, older eelgrass beds tend to be more diverse than newer younger beds (indication of more inbreeding)

- Wild celery is more genetically diverse in Chesapeake Bay than other systems
- CB research has shown that only certain genotypes of wild celery can grow in specific locations
- Reproduction is compromised in low diversity sites due to low probability of having both male and female plants and even for flowering to occur
- Genotypes differed in mean values (i.e., niche optima) for phenotypic traits that affect persistence: vegetative expansion: sunlight capture, as well as timing and frequency of production of flowers and turions

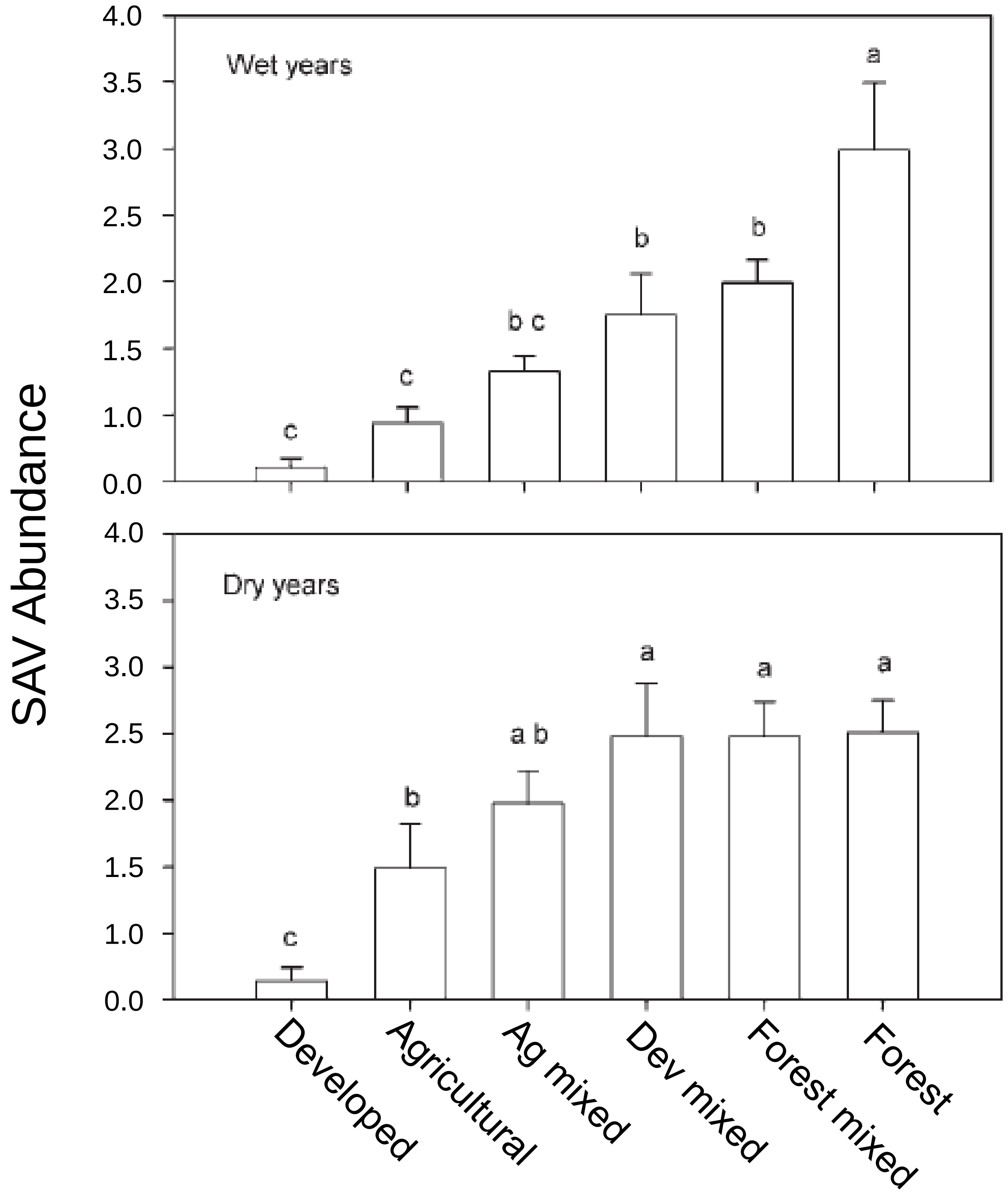
Effects of Land Use and Shoreline Armoring on Submerged Aquatic Vegetation

Weller, Patrick, Palinkas, Landry, Golden

- Heavily human-dominated watersheds have significantly less SAV abundance
- The SAV that is present in human dominated systems is generally less dense (except ag, possibly due to local nutrient enhancement)
- SAV beds tend to be smaller (narrower) in more human-dominated watersheds

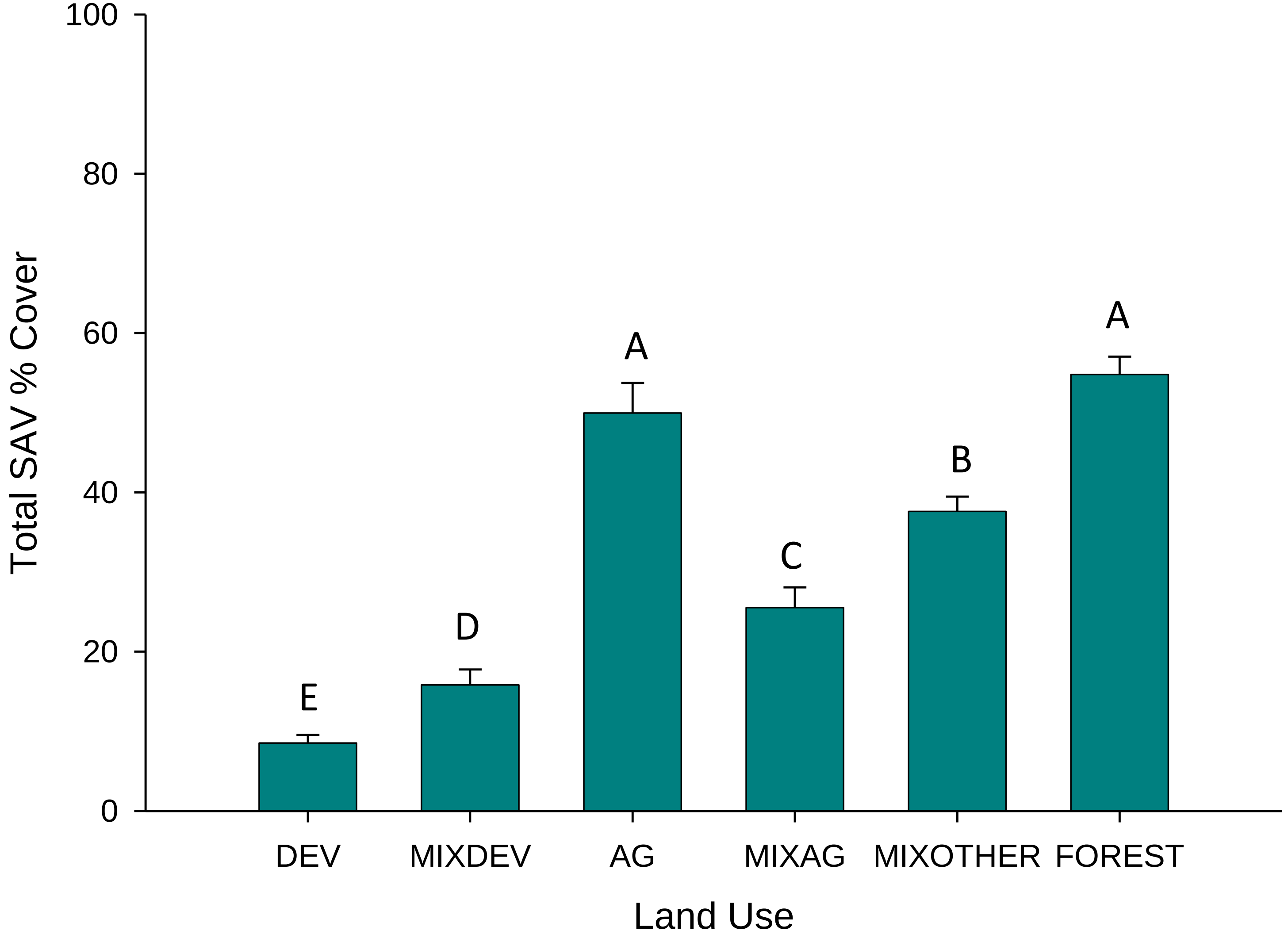
Interacting effects of land cover and weather

- SAV area normalized to habitat area & density weighted
- RM ANOVA
- Dev always low
- Ag better in dry years
- Forest better in wet years



Li et al. 2007. Estuaries & Coasts 30:840-854

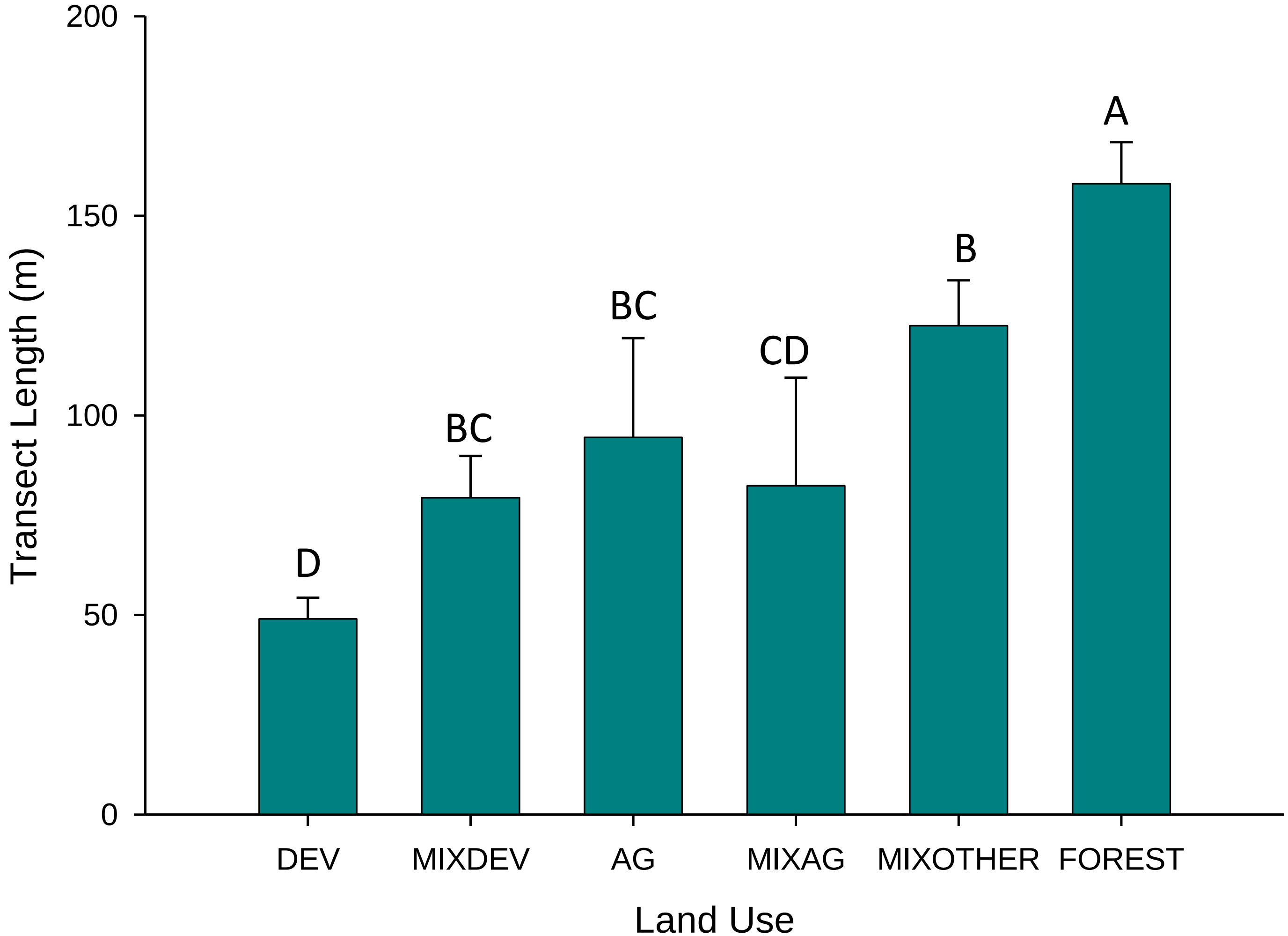
Watershed Land-use



-The farther from natural a watershed becomes, the less SAV it supports

Watershed Land-use

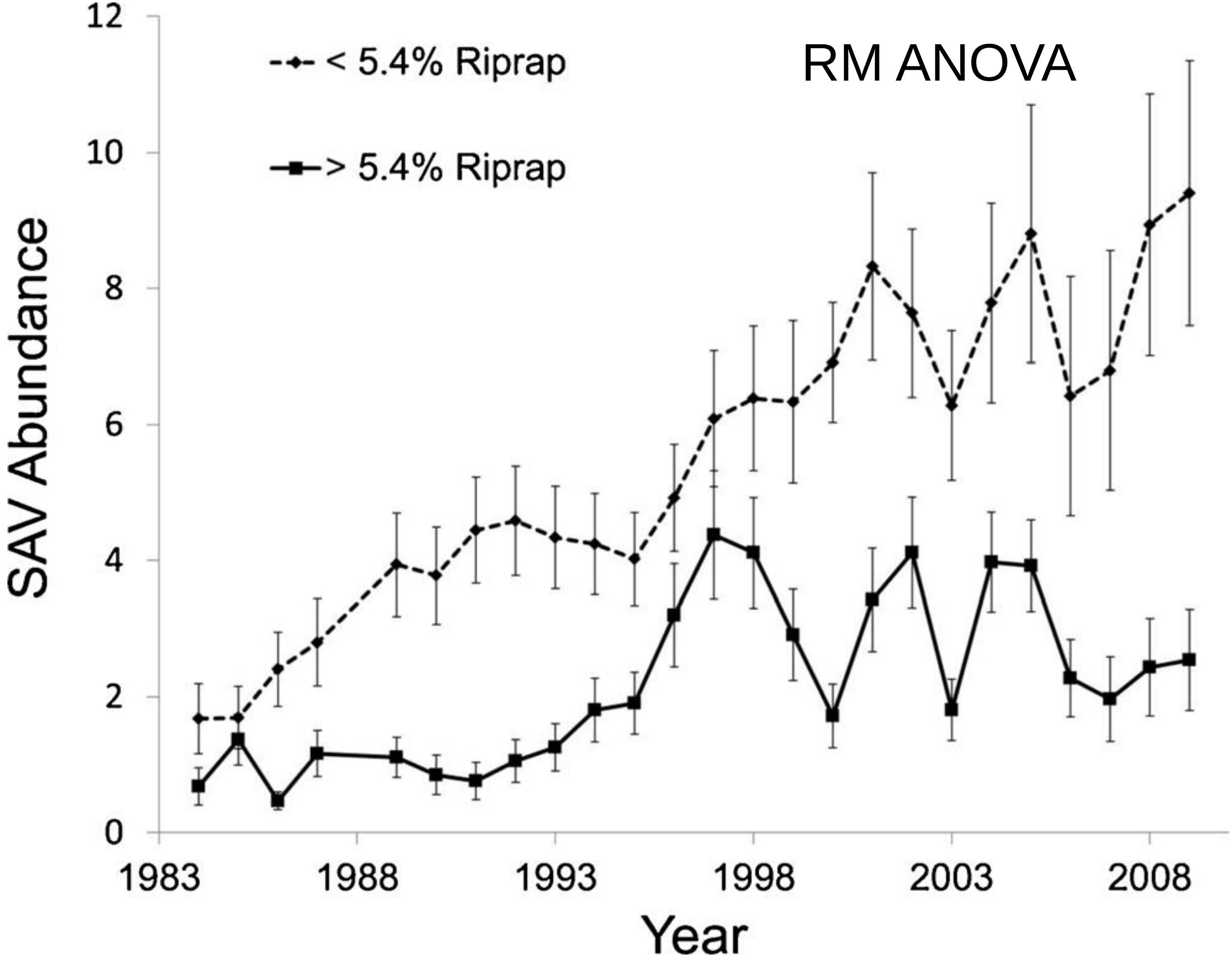
J. Brooke Landry



-SAV beds don't extend as far from shore as the watershed de-naturalizes

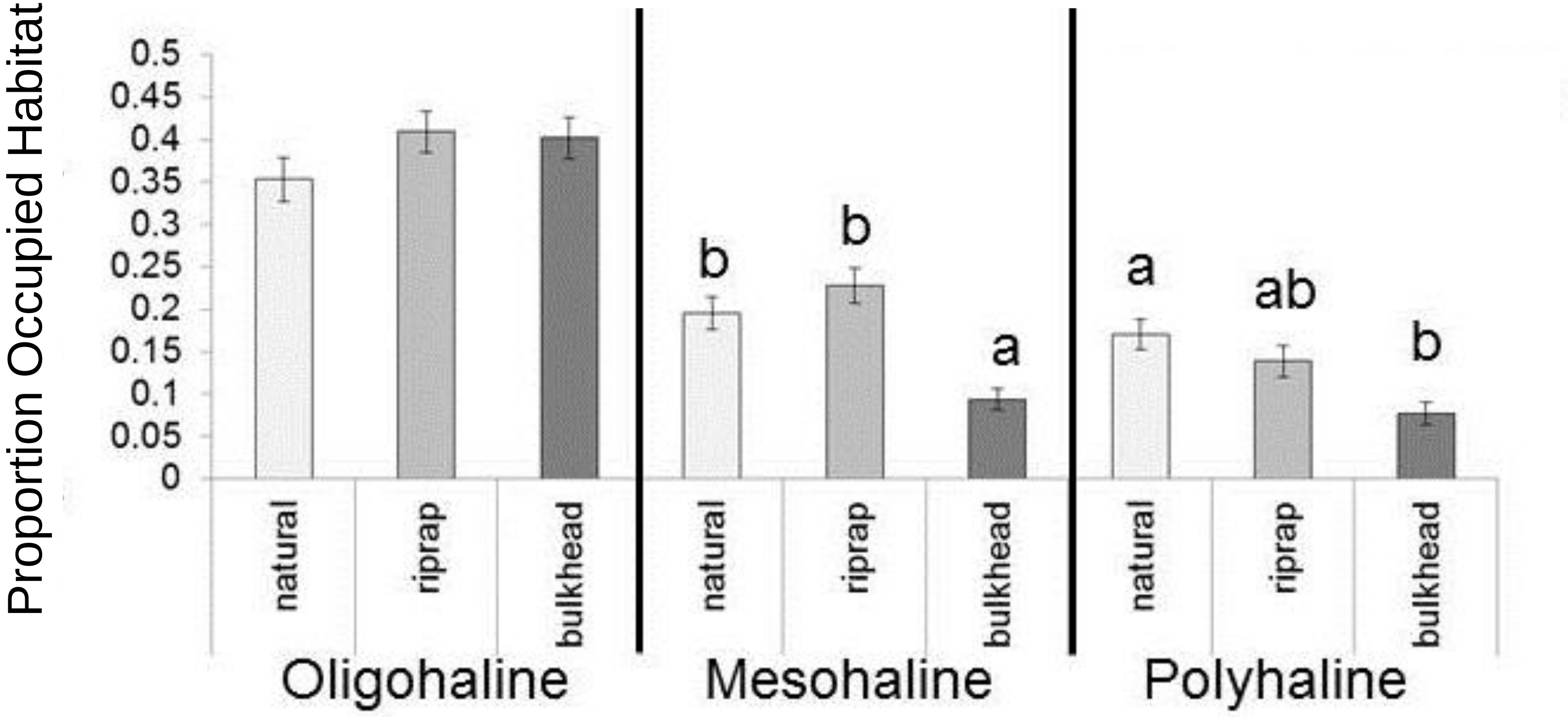
- When a subestuary has >5.4% of the shoreline in riprap, SAV abundance is significantly decreased
- Subestuaries with >5.4% riprap have lower SAV recovery trajectories
- The impact of shoreline armoring is more pronounced in the poly and mesohaline
- The impact of shoreline armoring is more pronounced in forested watershed than more human dominated ones (developed/ag dominated areas already heavily impacted)
- SAV beds are smaller, less dense and less diverse offshore of a riprap shoreline

Recovery trends differ with armoring



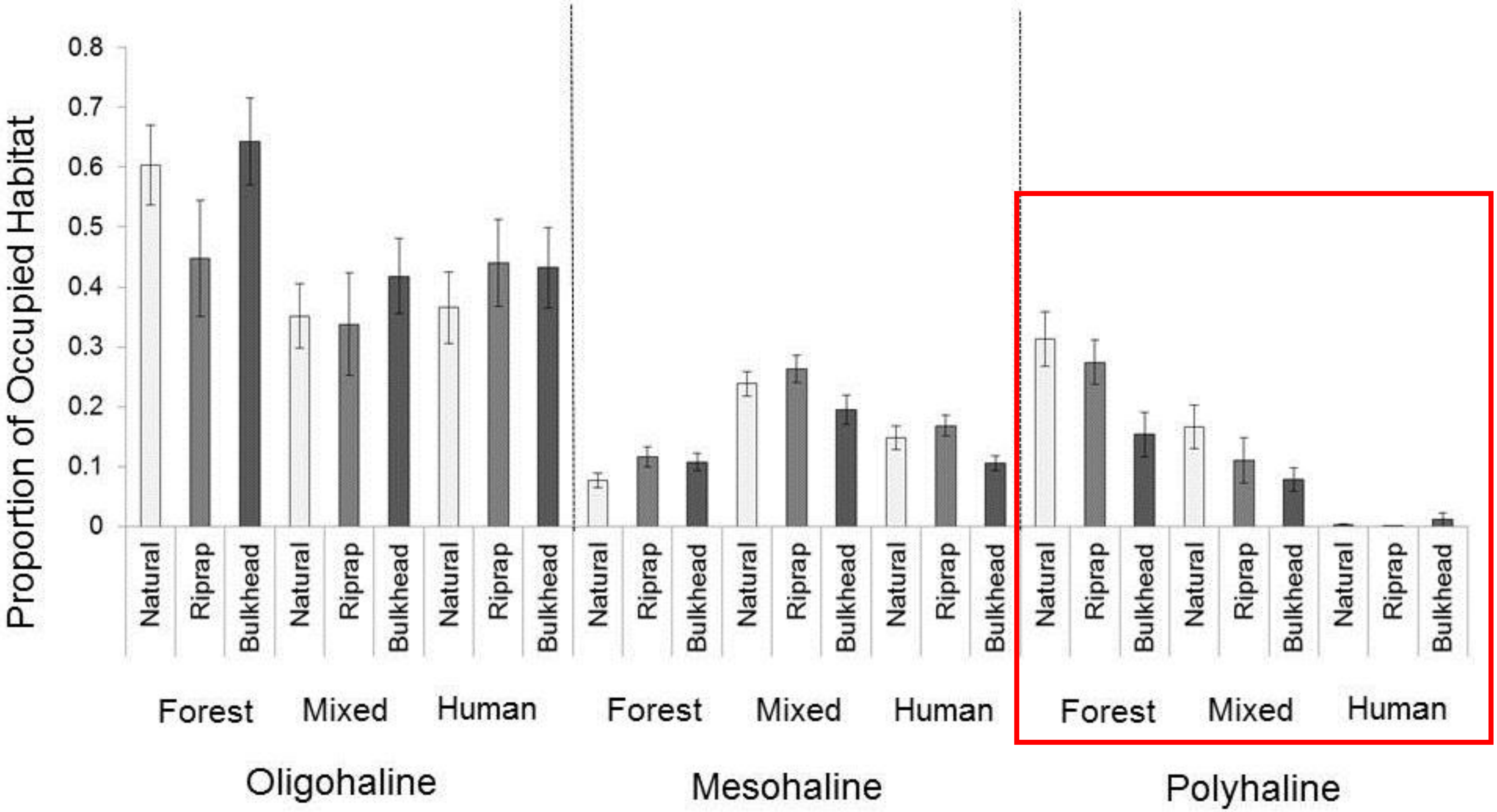
Patrick et al. 2014. Estuaries & Coasts 37:1516–1531

Armoring effects vary with community



Patrick et al. In review

Land cover constrains effects



Patrick et al. In review

Ecosystem Services Provided by SAV **Wainger**, Kennedy

- Anderson 1985, restoring 4,500 ac of SAV would improve value of Virginia's blue crab catch by $4.2m (1987 dollars)
- A loss of one ha of SAV could reduce commercial harvest by $5,409 Mykoniatis & Ready (2013)
- Jackson et al. (2015) in Med. estimate that 30-40% of commercial fishery revenue and 29% of recreational expenditures are associated with species that utilize seagrasses during at least one life stage.
- McArthur and Boland (2006) estimate that a ha of seagrass lost costs AU$235,000 per year in fishery stock value

- Other ecosystem services
  - Shoreline protection (not quantified)
  - Property values are enhanced when there is SAV offshore, by 5 to 6% Guignet et al. (2014)
  - Carbon sequestration is worth $600/ha/year
  - $2 to $8 per acre of SAV per year value of waterfowl hunting opportunities (Wainger et all)

Timeline going forward

- Have chapter authors submit final drafts of chapter by June 30, 2016
- Synthesize new HRs
- Editors and others draft combined introduction and executive summary by September 30, 2016
- Submit full document to EPA by 12/31/2016
- Submit manuscripts to peer-reviewed journals by 12/31/2016